Review

Involuntary Smoking in the Restaurant Workplace

A Review of Employee Exposure and Health Effects

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Objective.—To determine the relative exposure to environmental tobacco smoke for bar and restaurant employees compared with office employees and with nonsmokers exposed in the home (part 1) and to determine whether this exposure is contributing to an elevated lung cancer risk in these employees (part 2).

Data Sources.—MEDLINE and bibliographies from identified publications.

Study Selection.—In part 1, published studies of indoor air quality were included if they reported a mean concentration of carbon monoxide, nicotine, or particulate matter from measurements taken in one or more bars, restaurants, offices, or residences with at least one smoker. In part 2, published epidemiologic studies that reported a risk estimate for lung cancer incidence or mortality in food-service workers were included if they controlled, directly or indirectly, for active smoking.

Data Extraction.—In part 1, a weighted average of the mean concentration of carbon monoxide, nicotine, and respirable suspended particulates reported in studies was calculated for bars, restaurants, offices, and residences. In part 2, the relative lung cancer risk for food-service workers compared with that for the general population was examined in the six identified studies.

Data Synthesis.—Levels of environmental tobacco smoke in restaurants were approximately 1.6 to 2.0 times higher than in office workplaces of other businesses and 1.5 times higher than in residences with at least one smoker. Levels in bars were 3.9 to 6.1 times higher than in offices and 4.4 to 4.5 times higher than in residences. The epidemiologic evidence suggested that there may be a 50% increase in lung cancer risk among food-service workers that is in part attributable to tobacco smoke exposure in the workplace.

Conclusions.—Environmental tobacco smoke is a significant occupational health hazard for food-service workers. To protect these workers, smoking in bars and restaurants should be prohibited.

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THE ADVERSE health effects of environmental tobacco smoke (ETS) exposure are now well recognized.[1-4] The Environmental Protection Agency classified ETS as a group A carcinogen and estimated that it causes about 3000 lung cancer deaths per year in nonsmokers.[3] The workplace is a major source of ETS exposure, and the National Institute for Occupational Safety and Health has recommended that involuntary exposure to tobacco smoke be eliminated by prohibiting smoking in the workplace.[5] Many state and local governments have responded to this recommendation by prohibiting smoking in public and/or private workplaces.[6]

Many local governments have regulated smoking in restaurants.[7] These efforts have generally focused on protecting the public from ETS (Hatfield L. Face-off: smoking in restaurants? *San Francisco Examiner*. February 27, 1992: A1). However, restaurants are also workplaces, and because restaurant employees spend a much longer time in the restaurant than do patrons, ETS exposure is more likely to result in adverse health effects for them.

This review assesses the potential health hazard of ETS exposure for bar and restaurant employees. There are two questions considered. First, what is the relative exposure to ETS for bar and restaurant employees compared with employees of other businesses and with individuals who live in a home with a smoker? Second, does ETS exposure in bars and restaurants produce an elevated lung cancer risk among these workers? To answer the first question, published indoor air quality data for bars, restaurants, offices, and residences were reviewed. To answer the second question, the epidemiologic studies of lung cancer risk in food-service workers were reviewed.

METHODS

Literature Review

A literature search was carried out using the National Library of Medicine MEDLINE database to locate published studies that reported measurements of tobacco constituents in indoor air and studies of occupational lung cancer risk in food-service workers. Bibliographies from each publication were reviewed to identify additional relevant citations.

In part 1, studies were included if they met the following criteria: (1) reported the mean concentration of carbon monoxide, nicotine, or respirable suspended particulates from measurements taken in one or more restaurants, bars, offices, or residences with at least one smoker; (2) did not include measurements taken in designated smoking areas; and (3) did not include measurements taken under smoke-free conditions. Thus, these studies include measurements in restaurants and offices that allowed smoking anywhere, or in the nonsmoking areas of restaurants and offices that restricted smoking to a designated area. Measurements in residences were taken in the presence of at least one smoker. In addition to individual studies obtained through the computer search, three published reviews were

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Table 1.—Indoor Air Concentrations of Carbon Monoxide, Nicotine, and Respirable Suspended Particulates in Restaurants, Bars, Offices, and Residences*

Constituent	No. of Studies	No. of Sites Sampled	Weighted Mean†	Range	Ratio‡
Carbon monoxide, ppm					
Offices	12	1161	3.0	1.0-3.3	1.0
Restaurants	12	229	5.1	0.5-9.9	1.7
Bars	10	32	11.6	3.1-17	3.9
Nicotine, μg/m³					
Offices	22	940	4.1	0.8-22.1	1.0
Residences	7	91	4.3	1.6-21	1.0
Restaurants	17	402	6.5	3.4-34	1.6
Bars	10	25	19.7	7.4-65.5	4.8
Particulates, μg/m³					
Offices	19	912	57	6-256	1.0
Residences	13	624	78	32-700	1.4
Restaurants	12	211	117	27-690	2.0
Bars	10	16	348	75-1320	6.1

*Data from Sterling et al,[9] Repace,[10] Guerin et al,[10] and Turner et al.[11] No studies met the inclusion criteria for measurement of carbon monoxide in residences.

†Weighted average of individual study mean concentrations for all measurements taken. Weights used were the number of restaurants, bars, offices, or homes sampled.

‡Ratio of weighted mean restaurant, bar, or residence to weighted mean office concentration.

helpful in ensuring that most of the relevant literature was included in the analysis. First, Sterling et al[9] reviewed the published literature on air sampling of tobacco constituents as of 1982. Second, Repace[9] reviewed the results of about 50 studies of indoor ETS concentrations that were published before 1987. Third, the most recent and extensive review of the literature, published by Guerin et al[10] in 1992, reports the results of nearly 100 air-sampling studies. Finally, data from the largest single study of indoor ETS levels, in which Turner et al[11] tested 585 office environments, were included in this review and analysis. It should be noted that data from individuals or groups allied with and funded by the tobacco industry[11] were included in the analysis.

In part 2, studies were included if they met the following criteria: (1) reported a risk estimate of lung cancer incidence or mortality in food-service workers compared with other workers or with the general population; and (2) controlled, directly or indirectly, for the confounding effects of active smoking.

Data Analysis

In part 1, a weighted average of the mean carbon monoxide, nicotine, and respirable suspended particulates concentrations reported in each of the studies was calculated for bars, restaurants, offices, and residences. The weight given to each study was the number of separate restaurants, offices, or homes sampled. This weighting procedure resulted in heavier weighting of studies that reported the means of a large number of separate office or restaurant measurements. These studies are more likely to reflect typical workplace concentrations than those measuring concentrations in a single workplace.

In part 2, no attempt was made to statistically pool the individual lung cancer risk estimates, owing to the small number of studies and the variability in study designs.

RESULTS

Part 1: ETS Levels in Restaurant Air

The mean restaurant ETS constituent concentrations are between 1.6 and 2.0 times higher than those in the office workplaces studied, and 1.5 times higher than levels in homes with at least one smoker present (Table 1). Mean concentrations of ETS constituents in bars are 3.9 to 6.1 times higher than in the office workplaces, and 4.4 to 4.5 times higher than in the residences.

One must be cautious in comparing ETS exposure in the home and workplace based only on ETS concentrations in ambient air because the duration of exposure is different in each environment. Repace[9] has shown that total exposure is proportional to both concentration and duration of exposure. Based on time-budget studies that have estimated the average amount of time spent by working persons in various environments, the average US adult spends about 14 hours in the home and 6 hours in the workplace per day.[12] Allowing for 8 hours of sleep per day, and assuming that persons exposed to ETS at home are exposed during all waking hours, the duration of exposure is similar in the two environments (6 hours). Thus, total exposure to ETS is likely to be at least 1.5 times higher for restaurant workers than for persons who live with a smoker, and at least 4.4 times higher for bar workers than for individuals with only domestic ETS exposure.

Part 2: Health Effects of Restaurant ETS Exposure

Eleven studies have examined lung cancer risk in food-service workers without controlling for active smoking.[13-23] These studies were excluded from the analysis. Six studies have examined lung cancer risk in food-service workers, controlling for active smoking and other potential confounding variables.[24-32] One of these was a historical cohort study that examined occupational lung cancer mortality. Five were case-control studies that included incident lung cancer cases (Table 2).

Investigators in the California Occupational Mortality studies[24-27] reviewed California's mortality data from 1979 through 1981 by occupation.[24-27] Crude standardized mortality ratios (SMRs) were calculated for food-service workers. Singleton and Beaumont[25] and Beaumont et al[27] then attempted to control for smoking, alcohol, and socioeconomic status indirectly by adjusting for national occupational smoking and alcohol use rates (imputed from National Health Interview Survey data and average occupational socioeconomic status). For white male food-service workers, the unadjusted lung cancer SMR was 105% and the adjusted SMR was 125% (95% confidence interval [CI], 90% to 169%). For male bartenders, the adjusted SMR was 152% (95% CI, 118% to 192%). For white waitresses, the crude SMR was 368% and the adjusted SMR was 148% (95% CI, 125% to 174%).

Williams et al[28] conducted a case-control study using cancer mortality data from the Third National Cancer Survey. Occupational history and a range of potential confounders were determined by interview. Odds ratios (ORs) for working in various occupations were determined for a variety of cancer types, adjusted for smoking, alcohol, income, and education. For female food-service workers, the adjusted lung cancer OR was 1.88. For male food-service workers, no risk estimate was reported owing to the small number of cases (two).

Lerchen et al[29] studied the relationship between occupation and lung cancer among males in a case-control study using the New Mexico Tumor Registry. Cases and population-based controls were interviewed to obtain occupational and smoking histories. For males employed in the "eating and drinking establishment industry" category, an adjusted OR of 1.6 (95% CI, 0.8 to 2.9) was reported.

Schoenberg et al[30] examined the relationship between occupation and lung cancer in New Jersey males in a case-control study. Cases obtained from a state health department reporting system and

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Table 2.—Studies of Lung Cancer Risk in Food-Service Workers, Controlled for Active Smoking*

Source	Subjects	Study Design	Risk Estimate (95% Confidence Interval)	No. of Cases or Deaths	Additional Confounders Controlled
		Males			
Singleton and Beaumont[26]	California (deaths) Bartenders Other food-service workers	Historical cohort	 SMR=1.52 (1.18-1.92) SMR=1.25 (0.90-1.69)	 69 42	Age, sex, race, SES, alcohol
Larchen et al[29]	New Mexico (incident cases) Eating and drinking industry workers	Case-control	 OR=1.6 (0.8-2.9)	 26	Age, sex, race, diet
Schoenberg et al[30]	New Jersey (incident cases) Bartenders Other food-service workers	Case-control	 OR=. . . (1.2-1.3)† OR=. . . (1.1-1.2)†	 29 37	Age, sex race, SES, diet
Zahm et al[31]	Missouri food-service workers (incident cases)	Case-control	OR=1.8 (1.0-3.5)	24	Age, sex, race
		Females			
Singleton and Beaumont[26]	California waitresses (deaths)	Historical cohort	SMR=1.48 (1.25-1.74)	149	Age, sex, race, SES, alcohol
Williams et al[28]	US food-service workers (incident cases)	Case-control	OR=1.88	12	Age, sex, race, SES, alcohol
Keller and Howe[32]	Illinois females employed in eating and drinking places; nonsmokers (incident cases)	Case-control	OR=1.92 (1.21-3.07)	Not given	Age, sex, race

*SMR indicates standardized mortality ratio; SES, socioeconomic status; and OR, odds ratio.
†Specific OR not given in source cited.

population-based controls were interviewed to obtain occupational, smoking, and dietary histories. The adjusted OR for male bartenders was between 1.2 and 1.3, and for other food-service workers was between 1.1 and 1.2.

Zahm et al[31] conducted a case-control study to determine (after adjusting for smoking) the relationship between lung cancer and occupation. Data from the Missouri Cancer Registry, which includes occupational and smoking histories, were reviewed for white male lung cancer cases diagnosed between 1980 and 1985. The adjusted OR for food-service workers was 1.8 (95% CI, 1.0 to 3.5).

Keller and Howe[32] performed a case-control study using all incident lung cancers among nonsmokers entered in the Illinois Cancer Registry from 1985 to 1987. The controls were nonsmoking colon cancer cases. Unlike the other five studies, Keller and Howe's study controlled for active smoking by specification rather than adjustment. Only nonsmokers were included in the analysis. The OR for lung cancer in females employed in eating and drinking places was 1.92 (95% CI, 1.21 to 3.07). No risk estimate was given for males.

Taken together, these studies suggest that there is an excess lung cancer risk of approximately 50% (range 10% to 90%) among food-service workers compared with the general population, controlling for active smoking. In the two studies that examined bartenders and other food-service workers separately, this excess lung cancer risk was found for both groups of workers.[26,30] Thus, it appears that there is an elevated lung cancer risk in both bar and restaurant workers that persists after controlling for active smoking.

COMMENT

The availability of ambient air survey data on ETS levels in more than 1000 offices, more than 400 restaurants, and more than 600 homes provides an opportunity to estimate the relative ETS exposure of bar and restaurant workers compared with that of office workers and with that of individuals who live with a smoker. In this analysis, ETS exposure for restaurant workers was estimated to be 1.6 to 2.0 times higher than for office workers, and at least 1.5 times higher than for persons who live with a smoker. For bar workers, ETS exposure was estimated to be 3.9 to 6.1 times higher than for office workers, and at least 4.4 to 4.5 times higher than for persons exposed in the home. An attempt was made to determine whether this increased estimated workplace ETS exposure in bars and restaurants produces an increase in lung cancer risk for these workers. In six epidemiologic studies that controlled for active smoking, an excess lung cancer risk of approximately 50% (range, 10% to 90%) was found for food-service workers compared with the general population. This excess risk could well be due to the increased ETS exposure of food-service workers. However, there are several alternative explanations that must be considered.

First, residual confounding by smoking might explain the elevation in lung cancer risk for food-service workers. There are several reasons to believe that this is not the case. Three case-control studies that controlled for smoking[29-31] involved detailed smoking histories. Smoking status was measured as a categorical[31] or continuous variable,[29,30] incorporating duration and intensity of smoking. Moreover, the adjustment for smoking produced little change in the OR for males. Lerchen et al[29] reported a change in OR from 1.7 to 1.6 when smoking was added to the regression model. Schoenberg et al[30] reported a change in OR of no more than 0.1 for food-service workers when smoking was considered. The finding of an elevated lung cancer risk among female food-service workers in a study restricted to nonsmokers[32] adds further evidence that residual confounding by smoking is unlikely to explain the elevated lung cancer risk among food-service workers.

Second, confounding by a variable known to be associated with both lung cancer and food-service employment might explain the observed association. The most important considerations are age, sex, race, socioeconomic status, and diet (saturated fat and β-carotene [vitamin A] intake[33]). However, age, sex, and race were controlled in all six studies (Table 2). Socioeconomic status was controlled in three studies, and diet in two. Vitamin A intake, but not saturated fat intake, was specifically measured in these studies.[29,30]

Third, publication bias might explain why the six published studies reported an increased lung cancer risk in food-service workers. However, since these studies examine the relationship between lung cancer and a wide variety of occupations, they will almost certainly find a positive association with one or more occupations. Therefore, it is not plausible that studies finding no association between lung cancer and food-service employment have been differentially rejected or not submitted for publication.

Finally, the observed increase in lung cancer risk among food-service workers might be due to a carcinogenic exposure other than ETS. The most important consideration is exposure to cooking fumes. Air samples of cooking fumes have been shown to be mutagenic in the Ames assay,[34] and cooks have been shown to have elevated risks of respiratory tract cancers.[16,17,20,35-38] However, there are several reasons to believe that exposure to cooking fumes is not contributing substantially to the increased lung cancer risk among food-service workers. First, a study of the mutagenicity of restaurant air[34] suggests that ETS is the major contributor to the mutagenicity of air from dining areas. In this study, the mutage-

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nicity of air from dining areas was closely correlated with smoker density, but had no relation to the mutagenicity of air from kitchen samples. Second, ventilation in restaurants is generally designed to prevent cooking fumes from escaping into dining areas.[34] Average ventilation rates over cooking surfaces in four restaurants studied met the minimum requirements of the American Conference of Governmental Industrial Hygienists.[39] The most important source of exposure to cooking fumes in these restaurants was contamination in "cook's breathing zones during active work processes."[34] Third, a time-budget study of cooks found that only 33% to 60% of a cook's shift is spent over cooking surfaces.[34] Food-service personnel would be expected to spend a much lower percentage of their time in contact with air contaminants over cooking surfaces. Finally, the studies that have controlled for active smoking and examined lung cancer risk in cooks have not reported an elevated risk for these workers. Singleton and Beaumont[25] found an adjusted lung cancer SMR of 91% for males and 102% for females. Schoenberg et al[30] reported an adjusted OR of 0.9 for cooks. It is quite possible that the increased lung cancer risk among cooks is due to confounding by active smoking. Smoking rates in male cooks are 30% higher than in the general male population.[40]

An elevation in lung cancer risk attributable to ETS exposure in the restaurant workplace is plausible. Since domestic ETS exposure is associated with a relative risk for lung cancer of 1.3[1-3,25] and this review estimated that typical restaurant ETS exposure is at least 1.5 times higher than domestic exposure, an excess lung cancer risk over 30% in restaurant workers, compared with unexposed nonsmokers in domestic settings, would be expected. High levels of restaurant air mutagenicity[34] and increased levels of urine mutagenicity[41] and 3-aminobiphenyl,[42] a suspected carcinogenic hemoglobin adduct, have been demonstrated in ETS-exposed restaurant workers.

The effects of domestic ETS exposure[1-3] and ETS exposure in the workplace in general[5] have been recognized. This review of exposure to and health effects of ETS in bar and restaurant workplaces specifically addresses ETS as an important occupational health hazard for food-service workers. Public health efforts to regulate smoking in bars and restaurants can no longer focus only on protecting the patron. Food-service workers must be afforded the same public health protection as other workers. To protect these workers from the hazards of ETS, smoking should be prohibited in bars and restaurants.

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